The Slaughter of the Bison and Reversal of Fortunes on the Great Plains*

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I. Introduction

At the end of the 19th century, the North American bison reached near-extinction after declining from a stock of approximately 8 million to less than 500 (Taylor, 2011). For the Native Americans of the Great Plains, the Northwest, and the Rocky Mountains, this was the elimination of a resource that served as their primary source of livelihood for over 10,000 years prior to European settlement (Frison, 1991; Gilmore, Tate, Tenant, Clark, McBride, and Wood, 1999; O'Shea and Meadows, 2009; Zedeño, Ballenger, and Murray, 2014). For many tribes, the bison was used in almost every facet of life, not only as a source of food, but also skin for clothing, lodging, and blankets, and bones for tools. This array of uses for the bison was facilitated by generations of specialized human capital, which was accumulated partly in response to the plentiful and reliable nature of the animal (Daschuk, Hackett, and MacNeil, 2006). Historical and anthropometric evidence suggests that these bison-reliant societies were once the richest in North America, with living standards comparable to or better than their average European contemporaries (Carlos and Lewis, 2010; Prince and Steckel, 2003; Steckel, 2010; Steckel and Prince, 2001). When the bison were eliminated, the resource that underpinned these societies vanished in an historical blink of the eye. We show that the loss of the bison had substantial and persistent negative effects for the Native Americans who relied on them.[1] We suggest that federal Indian policy that limited out-migration from reservations and restricted employment opportunities to crop-based agriculture, prevented these nations from recovering in the long-run.

In some regions, the decline of the bison was a gradual process, beginning with the introduction of the horse and the arrival of European settlers. In other regions, the bison were eliminated through a mass slaughter that occurred within a period of just over ten years. The slaughter was, at least in part, spurred by a drastic improvement in European tanning technology that allowed bison hides to be transformed into commercially viable leather, thereby increasing the demand for bison hides internationally (Lueck, 2002; Taylor, 2011). Our empirical strategy exploits regional variation in the

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1We use the term Native American to broadly refer to the original inhabitants of North America, but acknowledge that this term is imprecise and is not without controversy (Corntassel and Witmer, 2008). We use it here because of its generality and common acceptance in the United States.

speed at which the bison disappeared as well as tribal variation in bison-reliance to determine the impact of the loss of the bison on the Native American societies that relied on them.

Our primary measures of bison-reliance are constructed by overlaying maps of the historic bison range and the timing of the bison's destruction (Hornaday, 1889) with maps of tribal ancestral territories (Gerlach, 1970; Sturtevant, 1981). This allows us to calculate the proportion of a nation's ancestral territory covered by the bison's range during the slow and rapid periods of its decline. To establish the contemporaneous impact of the elimination of the bison, we merge our measures of bison-reliance with data on the height, gender, and age of over 15,000 Native Americans collected between 1889 and 1903 by physical anthropologist Franz Boas (Jantz, 1995).[2] The tribe-age structure of Boas' data allows us to use a difference-in-differences strategy to compare age-height trends between societies that were affected by different stages of the bison's depletion. We find that nations that lost the bison most quickly suffered a 5 cm to 9 cm decline in height relative to those that lost the bison slowly. This decline more than eliminates the initial height advantage of bison-reliant people, providing the first empirical support for the contention of Steckel and Prince (2001) and Prince and Steckel (2003) that the people of the Great Plains derived this advantage due to their access to the bison. Using data from historical censuses, we find that bison-reliant nations suffered non-trivial increases in mortality, suggesting that our estimates may be viewed as lower bounds on the height differential.

Arguably, the decline of the bison was one of the largest devaluations of human capital in North American history, where a mass industrial restructuring was accompanied by low rates of inter-regional migration. The socioeconomic effects this type of restructuring have been of concern in relation to the decline of the American coal and steel industries in the 1980s (Black, McKinnish, and Sanders, 2003; Obschonka, Stuetzer, Rentfrow, Shaw-Taylor, Satchell, Silbereisen, Potter, and Gosling, 2017), and of the manufacturing sector in the early 2000s (Autor, Dorn, and Hanson, 2018). Our historical setting allows us to analyze how such a restructuring generates regional differences over a long time horizon. To do this, we use data from the Census Fact Finder compiled by Dippel (2014) to show that per capita income on reservations comprised of previously bison-reliant societies was approximately 30% lower in 2000, compared with reservations comprised of non-bison-reliant peoples. Further, we find that reservations whose members belonged to societies that lost the bison gradually had approximately 20% less income on average, while those whose members belonged to societies that lost the bison rapidly had roughly 40% lower incomes on average. Large income differences persist even when an extensive set of factors are accounted for.[3] Our long-run findings are robust to using an instrumental variables strategy that leverages the cost-adjusted distance between tribes' traditional territories and cities that were historically important for the trade in bison robes; and bounding the influence of unobservables following Oster (2018).

While migration has been shown to be an important margin of adjustment in other literature (e.g., Blanchard and Katz (1992); Hornbeck (2012)), the migration of Native Americans was practically much more limited until the 1960s (Gundlach and Roberts, 1978; Marks, 1998; Sorkin, 1969) and, if anything, we show that rapid-loss, bison-reliant nations likely experienced less migration than other nations and currently have significantly larger on-reservation populations. However, these larger on-

[2]We supplement our primary measure of bison-reliance with an anthropological index derived from historical accounts of bison-reliance, the share of a tribe's traditional territory that is covered by short grasses, a measure of cattle carrying capacity based on the 2012 U.S. Census of Agriculture, and tribal self-selection into the Inter-Tribal Buffalo Council.

[3]We control for historical centralization, forced coexistence, the timing of land cessions and railways, potential involvement in the fur trade and modern surrounding economic conditions and other factors that affect modern reservations.

reservation populations are not the driving force in the modern income differences we observe.

We provide evidence that limited occupational mobility is likely the driving force for the persistence of the shock. Crop-based agriculture was one of the only sectors permitted and incentivized by the Bureau of Indian Affairs (Daschuk, 2013; Iverson, 1997) until after the 1930s and many formerly bison-reliant nations, particularly those that lost the bison during the rapid slaughter, had limited pre-existing human capital in this sector. However, those bison-reliant nations that had agricultural practices prior to the bison's slaughter experienced a near complete economic recovery by 2000, despite facing a similar initial biological and economic shock. This suggests that when nations had opportunities to draw on pre-existing human capital, they were better equipped to adjust to loss of the bison in the long run and transition into other industries.

These findings have general implications for understanding regional disparities, large-scale job displacement, and intergenerational mobility (Chetty, Friedman, Hendren, Jones, and Porter, 2018; Chetty and Hendren, 2018a,b; Chetty, Hendren, and Katz, 2016; Chetty, Hendren, Kline, and Saez, 2014; Oreopoulos, Page, and Stevens, 2008; Solon, 1999; Stevens, 1997): even small, alternative viable sectors and industries that can be turned to in times of economic crisis can offer long-run reliance to the loss of a primary industry even when mobility is limited.

Our findings also build on the growing literature that offers a counter-narrative about the colonization of North America. The existing literature proposes that North America's wealth is a function of Europeans' choice to settle, which brought human capital and technology and led to the development of institutions that promoted growth (Acemoglu et al., 2001; Easterly and Levine, 2016; Nunn, 2014). However, Europeans were not importing their institutions or bringing their human capital to a blank slate; Indigenous institutions, resources, and human capital were affected in the process[4]. In the case we study, the core institutions of bison-reliant societies were eliminated and their human capital devalued in the process, resulting in implications for their growth and prosperity.

II. Background on Bison-Reliance and the Bison's Near-Extinction

Before European settlement, between ten to thirty million bison roamed the territory enclosed by the Rocky and Appalachian Mountains, the Mexican states of Chihuahua and Coahuila and the Canadian Northwest Territories (Hornaday, 1889; Lueck, 2002; Taylor, 2011). Anthropological evidence suggests that Indigenous peoples in these regions hunted the bison for at least 10,000 years prior to contact (Frison, 1991; Gilmore et al., 1999; O'Shea and Meadows, 2009; Zedeño et al., 2014).

While methods of hunting and employing the bison evolved over time, the largest change occurred when the horse was introduced to North America. Horses spread from Spanish-controlled regions of South America to as far north as Canada, likely through pre-existing Native American trade routes (Hämäläinen, 2003). By the 1650s, colonists had become aware of mounted Indians after encountering the riders of the Apache tribe. The introduction of the horse decreased the costs associated with hunting bison, leading some societies to shift from agriculture towards bison hunting as their main source of economic activity (Gwynne, 2010); however, it also brought the first waves of European diseases, infecting the people of the plains through their contact with Native horse traders who had

[4]See Akee (2009); Akee, Jorgensen, and Sunde (2015); Akee, Spilde, and Taylor (2015); Anderson and Parker (2008, 2009); Aragón (2015); Cornell and Kalt (2000); Dippel (2014) for a discussion of institutions, Feir (2016); Gregg (2018) for a discussion on human capital, and Aragón (2015); Leonard and Parker (2017); Leonard, Parker, and Anderson (2020) for a discussion of land and natural resources

been exposed to Europeans (Daschuk, 2013).[5] The earliest contact bison-reliant societies had with the English and French was through the fur trade, although this trade was typically indirect. Bison robes and pemmican were traded, but neither commodity was as lucrative as the furs being sought for resale in Europe. Bison-reliant peoples had been tanning hides for centuries, but the process was labor intensive and unprocessed leather from bison hides was not commercially viable from a European perspective (Taylor, 2011).

As settlement continued, the bison were hunted at higher rates, which when combined with years of drought and competition for food sources from settler cattle, slowly began depleting the bison populations east of the Mississippi (Isenberg, 2000). The pace of the bison's extermination drastically increased with the construction of the Pacific Railroad between 1863 and 1869. Upon completion of the railway, settlers had access to the herds of the interior in an unprecedented manner (Hanner, 1981; Hornaday, 1889). Even so, the historical accounts suggest that settlers and Native communities did not anticipate the bison's rapid extermination (Daschuk, 2013; Hanner, 1981). In fact, the construction of the railway through the Great Plains was made possible because of a series of treaties the United States negotiated during the late 1860s with the Apaches, Cheyenne, Kiowas, and the Comanche in the south, and North-Western Sioux and Northern Cheyenne—specifically the Teton Sioux, known as the Lakota—in the north.[6] Through these treaties, Natives exchanged large tracts of their ancestral territories for public goods, annuities, and protection of their exclusive right to hunt the bison herds. Many of the treaties included clauses that protected the bison from being hunted by settlers, which had resulted in a gradual decline of the herds in other areas of the country (Gwynne, 2010).

The fate of the bison changed markedly in 1871 when tanners in England and Germany developed a commercially viable method of tanning buffalo hides (Taylor, 2011). The European demand for hides spiked and in response, hide hunters flooded bison territory. Taylor (2011) estimates that in 1875, 1 million bison hides were shipped from the United States to France and England alone. The hide men initially focused on the more accessible southern herd, and by the spring of 1874, the herds on the middle plains had been decimated. A country once "black and brown with bison was left white by bones bleaching in the sun" (Gwynne (2010), p.260-261). By 1879, the southern herd was completely eliminated (Hornaday, 1889).

Several scholars have argued that the slaughter of the bison would not have happened in an environment with well-defined property rights (Benson, 2006; Hanner, 1981; Lueck, 2002; Taylor, 2011). As far as the Native nations were concerned, property rights existed through the treaties and those rights were simply not protected. One reason for this was political. Many military commanders believed that Native people would not be truly settled onto reservations until the bison were exterminated (Smits, 1994). Army Generals actively encouraged their troops to kill the bison for food, sport, or "practice". MacInnes (1930) argues that American soldiers drove bison herds south into the region of the hide hunters. According to estimates compiled by Taylor (2011), hide exports from the northern herd were one tenth of those of the earlier southern slaughter. One explanation for this is that after the slaughter began in the south, the American military saw it as an opportunity to weaken

[5]The extent to which Plains peoples were depopulated by European diseases has been intensely debated (Cameron, Kelton, and Swedlund, 2015). Early estimates suggest that, between 1774 and 1839, depopulation among Plains Natives was in the realm of 50%-60% (Decker, 1991), but later estimates suggest that this figure may be closer to 20% (Carlos and Lewis, 2012). Some historians have suggested that depopulation among the peoples of the Great Plains did not occur until *after* the extermination of the bison, when bison-reliant societies were on the brink of starvation and vulnerable to disease from malnutrition (Cameron et al., 2015; Daschuk, 2013; Daschuk et al., 2006).

[6]These treaties include, but were not limited to, the Medicine Chest Treaties of 1867 in the South and the Fort Laramie Treaty of 1868 in the North.

nations and their corresponding treaty rights and began to participate in the slaughter without commercial intentions. The bison were exterminated in northern Montana and Saskatchewan by 1878; in Wyoming and Alberta by 1880; the last bison hunt by the Sioux was in 1882 (Ostler, 2001); and the last bison in the remaining territory was gone by 1883 (Hornaday, 1889).

In less than two decades, the economic and social core of the great bison nations was gone. By the early 1880s, there were no bison, little game, and inadequate or non-existent government food supplies. Records from trading posts, Native leaders, Indian Affairs officials and media outlets reported widespread malnutrition and hunger among the Native populations (Cameron et al., 2015). Communities resorted to eating horses, mules, soiled food, and old clothing to prevent starvation (Daschuk, 2013; Gwynne, 2010). The resource that underpinned centuries of human capital acquisition was eliminated with few alternative options. Some communities resorted to collecting bison bones that littered the plains after the slaughter and selling them for fertilizer (Ostler, 2001).

Economic activity and mobility were severely constrained during this time period and arguably left few dimensions upon which Native Americans could adjust. Specifically, in both Canada and the United States, Native Americans could only leave their reservations with the permission of government officials on reservations, known as Indian Agents, until close to the 1930s (Daschuk, 2013; Marks, 1998). Cattle ranching, a plausible alternative use of skills for many bison peoples, was either actively prevented by Indian Agents or subject to credit constraints until the 1940s (Iverson, 1997; Trosper, 1978). Agriculture was effectively the only economic activity supported or promoted by North American governments. However, agriculture was abhorred by many in the former bison-reliant nations and few individuals had experience in the area (Gwynne, 2010; Iverson, 1997; Ostler, 2001). That being said, several nations had varying degrees of agricultural reliance prior to the bison's decline, which we show may have provided them with an economic alternative to help mitigate the negative consequences resulting from the loss of the bison (Iverson, 1997).

III. Data and Methodology

III.A Main Data Sources

We draw on a number of newly digitized and existing data sources from the 19th to 21st centuries, including data from anthropologists, ecologists, economists, historians, and government censuses. Here we briefly describe the construction of our main measures of bison-reliance, the timing of bison loss, as well as the primary outcomes and controls used throughout our empirical section. A more detailed description of our sources, variables, and data construction procedures, can be found in our full paper and online appendix.

Our primary measures of bison-reliance are generated from Hornaday (1889). At the end of the 19th century, William Temple Hornaday was commissioned by the Smithsonian Institute to construct a detailed account of the North American Bison and its elimination. As part of an extensive monograph, Hornaday published maps of the original bison range and of the timing and geographic nature of the bison's extinction. Figure 1 is a digital reproduction of Hornaday's map. The lightest region is the bison range as of 1730, the middle region is the bison range as of 1870, and the final black regions are the remaining herds as of 1889 with their corresponding sizes. The 1889 range was in ranched captivity. We construct our primary measures of bison-reliance by overlaying these ranges with digitized maps of ancestral territories from the Map of Early Indian Tribes in the National Atlas of the United States

(Gerlach, 1970), which are also displayed in Figure 1.[7]

We form a measure of initial bison-reliance using the overlay of the map of tribes' ancestral territories with the map of the bison's range as of 1730 to compute the proportion of a tribe's territory that was covered by the bison's range as of this time period. The next two variables we construct measure the timing of bison loss. The first is the proportion of territory that was covered by bison as of 1730 minus the proportion that was covered as of 1870. The second is the proportion of territory that was covered by bison as of 1870 minus the proportion that was covered in 1889. A large value of the first measure means that the region lost the bison gradually, as discussed in Section II, over a 140 year period. A large value of the second measure implies that the territory lost the bison rapidly, as a result of over-hunting in response to European demand for bison hides. By 1870 the number of nations whose ancestral lands were covered by more than 90% by the bison range had dropped from over 60 to approximately 10.

Using Hornaday's maps and the ancestral territory maps to construct measures of bison-reliance present some obvious drawbacks including both their potential lack of precision and the fact that the measures are entirely based on geography. The degree of bison-reliance among Native Americans–even in areas that were densely populated by bison–varied notably. For example, the Mandan peoples lived in the bison-dense territory of what is now North Dakota, yet they relied predominantly on agriculture and traded for bison meat and other supplies (Fenn, 2014). Our geographic measures would identify the Mandan as fully bison-reliant and among those that lost the bison rapidly. In order to account for these cases, we supplement our original measures of bison-reliance with anthropological accounts of bison-reliance taken from Waldman (2009). We also show that our results are robust to the use of three additional measures of bison-reliance that rely on ecological factors (including grassland ecology and a proxy for cattle carrying capacity) or self-identification (membership in the InterTribal Buffalo Council).

Given the lack of comprehensive income and occupation data for Native Americans pre-1900, we measure the immediate effects of the bison's decline using anthropometric evidence on childhood and adult height as biological indicators of well-being (Steckel, 1995, 2008). Between 1888 and 1903, a team of anthropologists led by Franz Boas collected measures of height, sex, age, tribal membership and "racial purity" of approximately 15,000 Native Americans in nearly all areas of North America (Jantz, 1995).[8] We supplement Boas' data with publicly available census data from the 1900 and 1910 IPUMS historical over-samples of Native Americans to evaluate changes in population size and child mortality (Ruggles, Genadek, Goeken, Grover, and Sobek, 2015).

To measure the long-run effects of the bison's decline, we focus on income per capita, relying on the sample of reservations compiled by Dippel (2014) from the 2000 American Census Fact Finder. These data include contemporary information on income per capita, population size, geographic isolation, ruggedness of terrain, and size of reservations; colonial information on forced co-existence and displacement from traditional territories; and pre-contact cultural characteristics from Murdock (1967), including measures of historic centralization, calories from agriculture, level of sedentariness,

[7]Following Dippel (2014), we use the ancestral territory maps from the National Atlas with augmentations from the Smithsonian Handbook of North American Indians (Sturtevant, 1981) to achieve a finer level of detail for some tribal territories.

[8]While there have been questions regarding the representative nature of Boas' sample (Komlos and Carlson, 2014), and of height data more generally (Guinnane, Bodenhorn, and Mroz, 2014), recent work comparing the Cherokee in Boas' sample to the Cherokee census suggests that Boas sample is representative on average, though it may over-represent the upper and lower classes (Miller, 2016). What is important for our empirical strategy is that, conditional on our set of covariates, over- or under-representation does not vary between age groups or between bison-reliant and non-reliant nations.

wealth distinctions, and the complexity of the location of each community. Our preferred specifications supplement Dippel's sample by controlling for whether a tribe was ever involved in one of the 23 major "Indian Wars" using an indicator from Spirling (2011), and the degree of differential depopulation from early exposure to European disease from the HYDE 3.1 database (Goldewijk, Beusen, and Janssen, 2010).

To evaluate the role of other characteristics and experiences that may have differed systematically between the slow- and rapid-loss bison-reliant nations, we estimate specifications with an expanded set of controls. These specifications account for the expansion of the railway into traditional territories (Atack, 2016), pre-settlement involvement in the fur trade, treaty-making, and differences across modern reservation environments. We also make use of a number of additional data sources to evaluate the mechanisms that explain the persistence of the shock. All additional controls and data sources are outlined in detail in the online appendix.

Table 1 presents summary statistics for Boas' sample in panel A and Dippel (2014)'s sample in panel B, as well as some of the additional controls we discussed above. We display summary statistics by classifying a nation as bison-reliant if 60 percent of its ancestral territory overlapped with the historic bison range and split the sample along this dimension in Table 1. In our empirical specifications, we use continuous measures of the proportion of share lost during various time periods as our primary variables of interest.

For Boas' sample, we focus on men to be consistent with prior literature (Prince and Steckel, 2003; Steckel and Prince, 2001), although we report our main results for women in the online appendix. The male sample consists of 8,788 individuals after restricting the sample to those under the age of 60 and dropping tribes that we are unable to clearly match to our primary measures of bison-reliance. From the first row of Table 1, we can see that bison-reliant nations are approximately 6 centimeters taller than non-bison-reliant nations and slightly less likely to have some non-Native American ancestry. They also tend to be slightly older. On average, operational railways entered the ancestral territories of bison-reliant nations at a later date. Since railways may proxy for the timing of contact and pace of settlement of non-Indigenous peoples, we control for the date of operation in a number of specifications. As described in the historical section, settlement on reservations occurred for bison-reliant peoples largely before the loss of the bison and the introduction of the railway. However, the date of local railway operation will proxy for relative timing of these factors as well.

Turning to the second panel of Table 1, we see that in 2000 per capita income on reservations comprised of formerly bison-reliant nations was approximately $2,100 lower compared to reservations comprised of non-bison-reliant nations. Bison-reliant nations were equally as likely as non-bison-reliant nations to engage in warfare, be displaced from their ancestral territories, be sedentary and have similar population densities in 1600; however, there are also notable differences. For example, perhaps not surprisingly, bison-reliant nations consume fewer calories from agriculture. They are also located next to slightly poorer counties, and are located farther from large cities.

Note that we also supplement our results using child mortality from the 1900 and 1910 Historical Census from the Integrated Public Use Data files that include an over-sample of Native Americans and information on occupation from these censuses as well as in 1930. These summary statistics are also included in the online appendix.

III.B Methodology

Our empirical strategy uses two primary specifications depending on the outcome variables we examine. The structure of Boas' data allows us to use a difference-in-differences estimation strategy based on a person's year of birth and the bison-reliance of their tribe, in order to identify the effect of loss of the bison on childhood and adult height. Let i denote the individual, n the Native nation, t the cohort, and H_{int} the height of the individual in centimeters. Then our estimating equation for the immediate effects of the decline of the bison can be written as:

$$\mathrm{H}_{int} = \beta_0 + \beta_1 \mathrm{B}_n + \beta_2 \mathbb{1}_t(\mathrm{BornNoBison}) + \beta_3 \mathbb{1}_t(\mathrm{BornNoBison}) \times \mathrm{B}_n + \mathrm{X}_{int}\boldsymbol{\theta} + \varepsilon_{int}, \qquad (1)$$

where bison-reliance is given by B_n, one of our continuous measures of bison-reliance or loss, and $\mathbb{1}_t(\mathrm{BornNoBison})$ is an indicator for the individual being born after the bison were eliminated. The coefficient of interest is β_3 which is the coefficient on the interaction of bison-reliance and the indicator for being born after the bison were eliminated. Each specification includes a matrix of controls, X_{int}, which includes a full set of age fixed effects to control for trends in height, as well as indicators for whether the individual is full blood, from Canada, and the expansion of the railway into traditional territories. Standard errors are clustered at the tribe-level. Given that bison-reliance is likely spatially correlated, we also report our main results using Conley (1999) standard errors in the online appendix. In some instances, these standard errors are slightly larger than those computed using tribe-level clustering, and in others they are slightly smaller.

The key assumption required for our difference-in-differences specification to be identified is that the height-trends of bison-reliant nations would have been the same as those of non-bison-reliant nations, were it not for the loss of the bison. We find strong evidence of this in an event-study design. Specifically, the coefficients on the interactions of bison-reliance with two-year-birth cohort fixed effects for those born before the start of the slaughter in 1871 are all close to zero and statistically insignificant.[9]

We consider those born after 1870 as being affected by the bison's decline. In some specifications, we compare trends in the heights of those that lost the bison rapidly to those that lost the bison slowly, in which case we use the date of 1886 as the cut-off for being born after the extinction of the bison. We use this year since the Sioux's last bison hunt was in 1882 and pemmican can last for nearly 3 years (Ostler, 2001), so that cohorts born after 1886 were almost surely born into a time without bison. Varying this date slightly has no qualitative effect on the results.

In some cases, we present estimation results from specifications that restrict the sample to include only individuals whose traditional territory overlapped the bison's original range by at least 60%. This allows us to compare those that lost the bison quickly–over a 10- to 20-year period–to those that lost the bison relatively slowly–over a hundred-year period–effectively holding unobservable characteristics constant across bison-reliant nations who would have been subject to similar government policies and had similar cultural backgrounds. In our most stringent specifications, we restrict the sample to those between the ages of 5 and 35.

To determine how the loss of the bison affected long-run per capita income, we estimate OLS regressions at the "reservation-tribe" level, following Dippel (2014), since tribal nations that may vary in historic bison-reliance may also share a reservation. Denote i as a reservation-tribe and n as

[9]Event-study results are reported in the full paper.

a nation, then the estimating equation is given as:

$$\mathrm{Y}_{in} = \alpha_0 + \alpha_1 \mathrm{B}_n + \mathrm{X}_{\boldsymbol{i}}\boldsymbol{\theta} + \mathrm{Z}_{\boldsymbol{n}}\boldsymbol{\Psi} + \varepsilon_{in}, \tag{2}$$

where Y_{in} is income per capita. We control for reservation-level characteristics in $\mathrm{X}_{\boldsymbol{i}}$, like the ruggedness of reservation terrain and surrounding counties' economic characteristics, cultural controls that vary at the level of the tribe in $\mathrm{Z}_{\boldsymbol{n}}$, such as whether the society was traditionally nomadic, the proportion of their calories derived from agriculture, whether the society exhibited observable wealth distinctions, or whether the society had an aristocracy. Finally, $\mathrm{Z}_{\boldsymbol{n}}$ also includes colonial controls that vary by tribe–whether the average society experienced forced co-existence (Dippel, 2014), the speed and timing of settlement in a society's ancestral territories, and whether the nation was displaced from their traditional territory. We cluster standard errors at the tribe-level, but report Conley (1999) standard errors for our main results table in the online appendix. As with the immediate effects, we find that in some cases the Conley (1999) standard errors are slightly larger and in others they are slightly smaller.

We examine the long-run impact of the bison's decline in two main ways. First, we use our full sample and differentiate between tribes whose traditional territories experienced the either a rapid or gradual loss of the bison. For these specifications we include two measures of bison-reliance: the reduction in a nation's traditional territory's bison-coverage as of 1870, "Share lost between 1730-1870", and the additional reduction between 1870 and 1889, "Share lost between 1870-1889". Our second and most stringent specification restricts the sample to those whose traditional territories overlap with the original range by more than 60%, allowing us to compare the outcomes of bison-reliant nations that lost the bison quickly to those that lost the bison gradually. The causal interpretation of our results relies on the speed of loss being conditionally uncorrelated with other unobservable differences between these societies. We then progressively add measures of observable differences that could otherwise explain differences in outcomes.

In addition to our base methodology, we use two additional empirical strategies that account for the possible importance of selection on unobservable factors. First, we use the methodology of Oster (2018) to bound the selection on unobservables, assuming the same degree of selection as on observables, as well as a threshold for the maximum allowable R-squared.[10] The second method uses an instrumental variables approach that leverages variation in the cost of traveling between tribes' ancestral homelands and cities that were historically important for either the trade in bison robes or, during the period of the slaughter, the trade in bison hides.

IV. Results

IV.A The Immediate Effects of the Bison's Decline

The results of estimating equation 1 are presented in Table 2. The first column shows that nations who lost the bison gradually, as measured by a large value of "Share lost between 1730-1870", were about 2 cm taller than all other Native nations, on average, but lost this height advantage after 1870.[11] In

[10] We follow the recommendations in Oster (2018) and assume a maximum R-squared of 1.3 times the R-squared from the controlled regression.

[11] Recall that each of our bison-reliance measures are continuous variables $\in [0, 1]$, so that a one unit change in "Share lost between 1730-1870", for example, can be thought of as moving from the scenario where there is no reduction in bison-coverage in a tribal territory by 1870 to that where the reduction in bison-coverage in a tribal territory is 100%.

column (2), we restrict our sample to nations that had at least 60 percent of their ancestral territory overlapping the 1730 bison range. Because nations could store pemmican for up to three years, we use being born after the date of 1886 as a cut off for being born into a world with no access to bison for those that were still bison-reliant as of 1870.

On average, nations that lost the bison quickly were slightly taller than other bison-reliant peoples, but after 1886 *more than their entire height advantage* was eliminated, with declines in height of up to 5 cm. The most dramatic estimates suggest that among those born into bison-reliant nations that lost the bison as part of the rapid slaughter, heights declined by 9 cm relative to those that lost the bison gradually. These results are estimated using the sample of individuals aged 5-35. Replicating Table 2 using females in the sample, supports a similar narrative, but females are notably under-represented in Boas' sample, so the results should be treated with caution. We have also estimated specifications that allow us to infer the effect of an additional growing year spent after the slaughter. These results suggest that for bison-reliant tribes that experienced the rapid slaughter, an additional year between the ages of zero to twenty-one without the bison would reduce one's height by 1.511cm (s.e. 0.811) relative to bison-reliant tribes who experienced the gradual decline. These results are unreported, but available upon request.

Komlos and Carlson (2014) note a decline in the height of Plains Indian scouts in the U.S. Army after the Civil War; however, they do not connect this to the loss of the bison, nor do they explicitly examine trends in heights by the age or bison-reliance of the individual. Our results present an explanation for their findings. It is also important to note that it is unlikely that settlement on reservations is able to offer a reasonable alternative explanation for our findings for two reasons. First, there was a lack of a sharp change in reservation policy after this time period. Second, Steckel (2010) shows that the number of years on a reservation if anything is positively correlated with height on the Great Plains. That being said, there may be a concern that our results are driven by differential penetration of the railway and thus European settlement over this time period. Hence, in columns (3) to (6), we control for the number of years since the railway first entered an individual's tribal territory and whether an individual was born after the first railway entered their traditional territory. Although we see that for every year after someone was born after the introduction of the railway to their territory they are approximately 0.5 cm shorter, this does not significantly diminish the effect of the loss of the bison.

Table 1 showed that bison-reliant nations were slightly older than non-reliant nations. Motivated by this finding, we plot the age distribution of bison-reliant and non-reliant nations, which reveals large differences in the number of individuals under the age of 20, suggesting higher levels of youth mortality among bison-reliant nations.

We further examine whether there is evidence of a population decline after the rapid extinction of the bison by estimating the effects of the bison's decline on cohort size using the 1900 and 1910 IPUMS historical over-samples. Relative to non-bison-reliant tribes, bison-reliant tribes experienced an increase in cohort size. Restricting the sample to only bison-reliant nations reveal that those who experienced the rapid decline saw declines in cohort size of up to approximately 60 people relative to those who experienced the gradual decline; however, these results are estimated with a substantial degree of noise and hence not reported here.

As a more direct measure of mortality, we use data on the proportion of children ever born who survive from the 1900 and 1910 IPUMS historical over-samples as reported by their mothers. Since we do not know the age of the child's mother at the death of each (or any) of their children or the child's age, we cannot use a difference-in-differences structure for this exercise. Thus we estimate equation 2, where our dependent variable is the proportion of children surviving for a given mother. The equations are estimated using OLS, but are robust to using a binomial model on counts of births and deaths. We weight the regression by the census person weight multiplied by the number of children a woman has and the standard errors are clustered at the tribe level.

Table 3 presents the results from this exercise. The first three columns display the results for the full sample and the last three columns restrict the sample to only those who were bison-reliant. Conditional on age, whether the mother is literate, and geographic region, women who belonged to bison nations that lost the bison rapidly have 10 percent fewer of their children surviving relative to those mothers whose tribes were never bison reliant. Restricting the sample to only include mothers whose tribe was at one-time bison-reliant reveals that those who lost the bison rapidly have about five percent fewer of their children surviving as of 1900 and 1910. We see this as direct evidence of higher mortality in bison societies after the slaughter of the bison.

Taken together, our results consistently indicate that bison-reliant nations experienced substantial declines in physical well-being after the bison's decimation. These results hold across numerous data sources and are particularly poignant for nations that experienced the rapid slaughter. Given that the declines in height among bison-reliant nations were coupled with increases in mortality, the height effects we observe are likely a lower bound on the true consequences of the loss of the bison.

IV.B Long-Run Persistence Among Bison Societies

This section examines whether the economic shock generated by the bison's decline led to long-run differences in well-being between bison-reliant and non-bison-reliant nations. Unconditionally, reservations comprised of tribes whose territories completely overlapped with the historical bison's range have roughly $2,500 lower income per capita in 2000 compared to those whose territories did not overlap with bison's original range. Losing the bison as part of the slaughter is associated with $3,800 lower income per capita, while losing the bison as part of the gradual decline is associated with $1,600 lower income per capita. These differences are substantial given that the average income in 2000 among reservations in our sample is only $10,500. Given that the descriptive statistics we showed that formerly bison-reliant nations are systematically different than non-bison-reliant nations, Table 4 reports estimates of the relationship between bison-reliance and income per capita, conditional on a set of cultural, geographic, colonial, and modern economic factors.

Systematically, we find that formerly bison-reliant nations make less on average, even after conditioning on the income per capita of nearby counties. Those that lost the bison as part of the slaughter (columns (4)-(6)) make less than those that had time to adjust to the bison's gradual elimination from their territory. The results are less precisely estimated in our most restrictive specifications, but the point estimate remains large and negative. In the online appendix, we show that our results are qualitatively consistent for each of our alternative measures of bison-reliance and our results hold if we use nighttime light density to proxy for economic activity, allowing us to expand our sample size to include reservations for which public data on income per capita is not available. In the full version of the paper, we also show our results are robust to an expanded set of control variables including regional fixed effects to generically control for fixed factors that would be correlated within Bureau of Indian Affairs regional divisions, the speed and timing of settlement by conditioning on the presence and timing of the railway entering into a nation's ancestral territory, controlling for the date the last treaty was signed between each nation and the federal government, early exposure to European trading using a proxy for the degree of involvement in the fur trade: the proportion of traditional territory that was covered by the historical range of the beaver and an extended set of modern controls including modern soil quality.

Similar results are shown for Canada in the online appendix where we condition on a number of available controls that are comparable to those used with the American data. We do not find large differences between bison-reliant nations who lost the bison gradually compared to those that lost the bison quickly. Presumably this is because there is not sufficient variation between those that lost the bison quickly compared to slowly, as evident in Figure 1. The Canadian results are important partially because they provide evidence that income differences between bison-reliant and non-bison reliant nations are not due to specific historical events that may have impacted bison-reliant Nations differently in the U.S.; potentially most importantly, the *General Allotment Act (GAA) of 1887* and other associated acts. Previous research has shown that those nations heavily impacted by these acts are worse off than other nations (Leonard et al., 2020), but allotment never occurred in Canada, thus cannot explain why previously bison-reliant nations are some of the lowest-income communities in North America.

Although our results cannot be fully explained by observable confounding factors, there may still be concern that some remaining unobservable factor may bias our findings. We use two separate methodologies to account for the potential selection on unobservables. The first uses the methodology of Oster (2018) to bound the influence of unobservables assuming the same degree of selection as on observables. The second method uses an instrumental variables approach. We use both these methodologies focusing on only those nations who were historically bison-reliant and compare tribes who lost the bison quickly to those who lost the bison gradually, effectively balancing the unobservables that are common across all bison-reliant nations.

The OLS coefficient from this exercise, repeated from column (6) of Table 4, is reported in column (1) of Table 5 for comparison. Column (2) applies the methodology of Oster (2018) to the coefficient on "Share lost between 1870-1889" to compute the implied bias of the coefficient estimate. Following the recommendation in Oster (2018), we assume that the degree of selection on unobservables is proportional to that on observables and set our maximum R-squared to be equal to 1.3 times the R-squared using our standard controls.[12]. The coefficient estimate increases slightly in magnitude from the OLS estimate of -1551.0 to -2030.3.[13]

Next, we turn to an IV specification that leverages the cost of traveling between tribes' ancestral homelands and historical cities that were important for the trade in bison robes. Identification here is grounded in the idea that these costs would be correlated with the speed at which bison were removed from traditional homelands, but uncorrelated with outcomes over 100 years later, other than through their effect on the loss of the bison. Since it is possible that proximity to important historical cities may be correlated with other forms of colonial contact or pre-contact conditions, we include our standard set of controls from Table 4 in all regressions. For more details on the construction of these costs, see the full paper and the online appendix. Since the data sources for the transportation costs to Montreal (Inwood and Keay, 2013, 2015) differ slightly from those to other cities (Donaldson and Hornbeck, 2016), we estimates separate IV specifications with Montreal–column (3)–and without Montreal–column (4). The IV estimate in column (3) is slightly larger in magnitude than the OLS

[12]This recommendation is based on a threshold value for the maximum R-squared for which 90% of a sample of randomized results from leading economics journals would survive.

[13]Since the implied bias provides an adjustment to the coefficient estimate, there is no standard error to report from this exercise.

estimate in column (1). It indicates that tribes whose territory lost 100% of bison during the rapid slaughter have an average of $1826.0 less per capita income today. Excluding Montreal does not alter this finding. The OLS estimates are further supported by the endogeneity test: the *p*-value for the test of the null hypothesis that the share of territory lost between 1870 and 1889 can actually be treated as exogenous is 0.513 in column (3) and 0.618 in column (4). The results from using the bias correction from Oster (2018) and the IV strategy provides evidence that our main OLS results slightly underestimate the magnitude of the effect of the bison's decline.

IV.C Mechanisms: Margins of Adjustment and Channels of Persistence

In this section, we consider the mechanisms that might explain the persistently lower economic well-being of bison-reliant nations into the present. Our main objective is to determine the margins along which individuals and societies were able to adjust to the loss of the bison and along which margins they were inhibited from adjusting.

We begin by considering whether geographic mobility might be an explanatory factor. First, it is unlikely that greater out-migration or more selective out-migration from the reservations of formerly bison-reliant nations explains the persistence. Results not presented here show that, even conditional on income, on-reservation bison-reliant populations are non-trivially larger and are more highly-educated than non-bison-reliant nations, even conditional on income.[14] Additional evidence for why it is unlikely that lower out-migration rates explain the persistence is suggested by using our expanded set of controls which includes the adult population share and total reservation population. Thus differential migration is unlikely to fully explain the persistence.

Rather, we argue that limits to early occupational adjustment can explain variation in persistence.[15] Specifically, we hypothesize that after the bison's decline, the human-capital acquired by bison-reliant communities with traditional experience in agriculture would have been valuable, especially since the agriculture sector was promoted by the Bureau of Indian Affairs.

We explore this possibility using a measure of historical experience with agriculture with an index of calories consumed from agriculture that we take from Murdock's Ethnographic Atlas. In the full paper, we show that even those bison-reliant nations that had some historical experience with agriculture suffered similar biological shocks in the short-run. Specifically, the interaction between bison-reliance and calories from agriculture are small and statistically insignificant in models of height and child mortality. However, in 1900 and 1910, bison-reliant nations that also had some historical experience with agriculture have a higher occupational rank than those that had less.

Table 6 reports the long-run consequences with initial economic diversification in agriculture. For nations that lost the bison rapidly, a larger share of calories from agriculture mitigates up to 90% of the negative long-run effect of the bison's loss. These results are consistent with the hypothesis that bison-reliant tribes that were diversified in sectors agreeable to and supported by the Bureau of Indian Affairs were able to mitigate most of the negative effects of the bison's decline. It is worth noting that it is diversification in crop-based agriculture in particular that is relevant here. A natural alternative use of the land and human capital previously acquired by the non-agricultural bison nations may

[14] See full paper for results on population. Results on education are forthcoming.

[15] We have also explored mechanisms related to historical trauma which are not included here since they are more speculative in nature. These results found that suicide rates and news stories of corruption and conflict are higher among bison-reliant tribes compared to those who were not bison-reliant. While these results are only suggestive, they provide evidence in line with the idea that societal channels beyond economic forces may also aid in explaining the long-run persistence of the economic shock.

have been cattle ranching. However, as suggested by Trosper (1978), limited access to capital markets as late as the 1960s prevented Native American ranchers from producing the same level of output as non-Native ranchers. We provide additional support for this in the complete paper by showing using data from the 1910 IPUMS historical over-sample to demonstrate that bison reliant nations were significantly less likely to be engaged in live-stock occupations than whites within their same county.[16]

V. Conclusions and On-Going Revisions

At the beginning of the 19th century, the North American bison roamed the Great Plains in the tens of millions, but by 1880, the bison were nearly extinct from a mass slaughter that occurred within as little as 10 years. This is the first paper to empirically quantify the long-run effects of the slaughter on the Native Americans who relied on the bison for over 10,000 years prior to its extinction. We compile historical, anthropological, ecological, geographic, and modern economic data to show that the elimination of the bison affected the well-being of the Indigenous peoples who relied on them, both immediately after the bison's decline, and up to 130 years later. We argue that the loss of the bison resulted in a reversal of fortunes: historically, bison-reliant societies were among the richest in the world and now they are among the poorest. We suggest that the primary channel through which the shock persisted was initial differences in the ability to re-specialize in other occupations, specifically crop-based agriculture which was one of the few occupations that was supported by the Bureau of Indian Affairs throughout the twentieth century.

We are currently in the process of re-drafting the full paper in response to referee comments. We are engaging in a new digitization of tribal territories, and have had to reconstruct all of the GIS measures in the original paper. The re-estimation is complete for most specifications and all the results tested so far are qualitatively consistent with the original paper. A number of the suggested revisions have been made in this shortened version, but a number of others remain. Specifically, we will be including 1) more direct evidence that the *General Allotment Act* did not differentially effect formerly bison-reliant nations;[17] 2) a clearer choice of the primary control and treatment group and measure of dependence to streamline the paper;[18] 3) additional evidence for the mechanism of persistence and more evidence that selective or lower migration rates were not the primary drivers of our long-run findings;[19] and 4) a stronger case for what the paper contributes to the general economics literature beyond Indigenous economic outcomes. We would greatly value participant feedback along these dimensions and of course, welcome all feedback generally.

[16] We only use this year because, to our knowledge, it is the only year that breaks out stock-based agriculture from other agriculture.

[17] We believe the Canadian results are sufficient for this, but we also now have data on allotment, fractionation, and land tenure and have confirmed that this is not driving the results.

[18] Our main treatment group in the revision is those nations whose territory intersected with the bison range at the start of the rapid slaughter and who relied on the bison according to a carefully constructed, revised anthropological measure. Our main comparison group is nations who never relied on the North American Bison as suggested by the editor.

[19] We are doing this in a number of ways: we are showing reserve populations over time approximately by decade from 1915 to 2010, conditioning on the rate of net out-migration inferred from population size and birth and death rates in the income regressions, and controlling for the proportion of the reserve population that has a college degree and is of working age.

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Figures and Tables

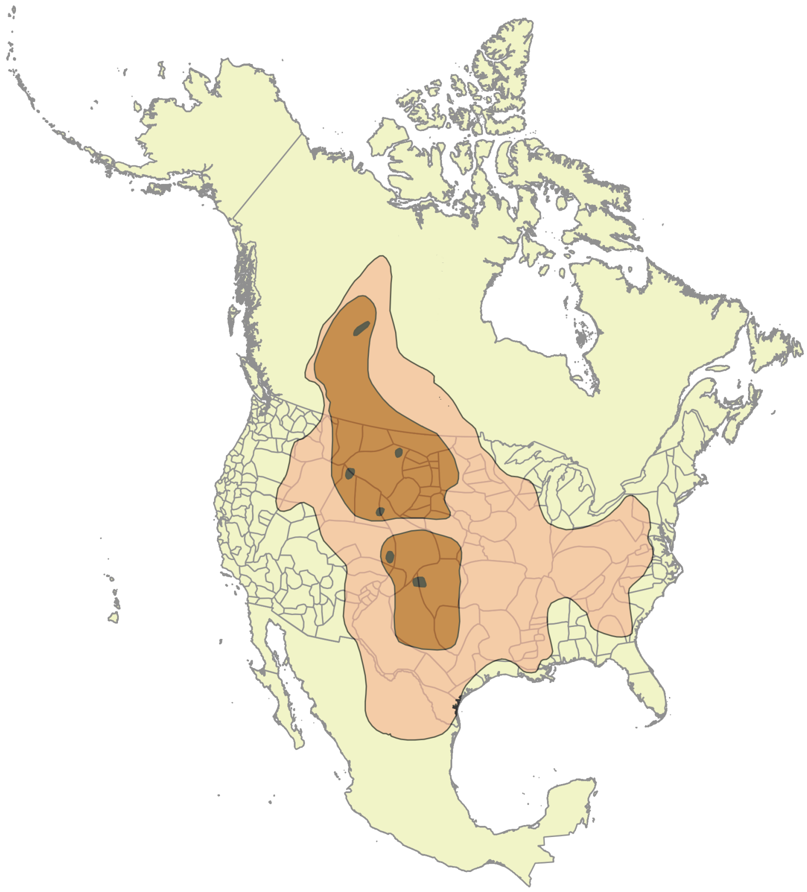

Figure 1: This is a digitized version of the map generated by Hornaday (1889), illustrating the original range of the North American bison and the timing of its decline. The lightest region is the range as of 1730, the middle region is the bison range as of 1870, and the final black regions are the remaining herds as of 1889 and their sizes. The 1889 ranges were in ranched captivity. Tribal territory boundaries are also displayed for the continental U.S.

Table 1: Summary Statistics for Boas and Dippel Samples

	Not Bison-Reliant (1)	Bison-Reliant (2)	Diff (3)
Panel A: Boas Sample 1889-1903			
Standing Height in cm	156.44	162.01	-5.57***
	(20.40)	(17.11)	
Year of Birth	1867.23	1865.40	1.83***
	(15.14)	(14.30)	
Age	25.33	26.33	-1.00**
	(15.14)	(14.12)	
Born After Rail	0.41	0.39	0.02*
	(0.49)	(0.49)	
Born During War	0.03	0.08	-0.06***
	(0.16)	(0.28)	
Only Native American Ancestors	0.80	0.78	0.02**
	(0.40)	(0.41)	
Observations	5104	3684	8788
Panel B: Dippel (2014) Sample 2000			
Per Capita Income	10751.89	8629.64	2122.25**
	(5066.94)	(4005.72)	
Indian War	0.50	0.62	-0.13
	(0.50)	(0.49)	
Distance Displaced	11.74	11.97	-0.23
	(1.03)	(0.95)	
No Railway in Territory	0.09	0.01	0.08*
	(0.29)	(0.12)	
EA Calories Agriculture	1.49	2.68	-1.19**
	(1.85)	(2.90)	
EA Sedentary	3.01	3.42	-0.41
	(1.63)	(2.26)	
Population in 1600	1.94	1.97	-0.03
	(3.47)	(3.24)	
Nearby Income Per Capita	18473.42	17438.36	1035.06*
	(2927.76)	(2874.21)	
Log Distance to Nearest City	3.42	4.07	-0.65***
	(1.14)	(0.81)	
Observations	123	72	195

Notes: This table displays sample means with standard errors below in parentheses. For specific variable descriptions and sources please refer to Section III.A and the online appendix. Column (1) reports these summary statistics for non-bison-reliant tribes, which we define as having ancestral territory that overlaps less than 60% with the original bison's range. Column (2) reports the summary statistics for bison-reliant tribes, which we define as having ancestral territory that overlaps more than 60% with the original bison's range. Column (3) reports difference in means tests between column (1) and (2), $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 2: The Impact of the Loss of the Bison on Male Native American Height

	(1)	(2)	(3)	(4)	(5)	(6)
I(Born After 1870)X Shr lost btw 1730-1870	-2.051**			-2.116*		
	(0.966)			(1.145)		
Shr lost btw 1730-1870	2.062*			1.792		
	(1.087)			(1.143)		
I(Born After 1870)	1.467*			1.626**		
	(0.785)			(0.799)		
I(Born After 1886)X Shr lost btw 1870-1889		-5.507**	-9.435**		-4.467**	-4.606
		(2.316)	(3.543)		(2.161)	(3.607)
Shr lost btw 1870-1889		1.708**	1.651**		1.261	0.887
		(0.786)	(0.777)		(1.059)	(1.021)
I(Born After 1886)		4.714***	6.486**		3.167	3.664
		(1.648)	(2.424)		(2.065)	(2.243)
Year of Birth	-1.416***	-1.711***	-2.082***	-1.407***	-1.679***	-2.064***
	(0.338)	(0.031)	(0.048)	(0.338)	(0.039)	(0.053)
Year Sampled	1.164***	1.304***	1.477***	1.141***	1.561***	1.846***
	(0.353)	(0.220)	(0.288)	(0.354)	(0.121)	(0.158)
Canada	-0.869	0.877**	0.783*	-0.756	0.874	0.734
	(0.902)	(0.422)	(0.435)	(0.780)	(0.625)	(0.585)
Only Native Ancestors	-1.153***	-1.207**	-1.263***	-1.180***	-1.250***	-1.296***
	(0.363)	(0.467)	(0.459)	(0.337)	(0.448)	(0.438)
# Yrs Since Rail				0.00197	0.0174	0.0298*
				(0.019)	(0.011)	(0.017)
Born After Rail				1.578**	-0.333	-0.684
				(0.619)	(0.619)	(0.684)
# Yrs Born After Rail				-0.0531**	-0.0423*	-0.0563*
				(0.025)	(0.024)	(0.029)
Born During War				2.055***	1.962***	1.656**
				(0.634)	(0.715)	(0.755)
Observations	8788	3684	2597	8788	3684	2597
Adjusted R^2	0.875	0.861	0.868	0.877	0.863	0.870
# of Clusters	132	49	47	132	49	47

Notes: This table reports OLS estimates of the difference-in-differences specification relating height to bison-reliance (equation 1). The dependent variable is standing height in centimetres. In addition to the controls displayed, we include a full set of age dummies in all columns. Note that the data on wars and railways is only available for American tribes. Thus specifications reported in columns 4-5 include a dummy and interaction for Canada to account for missing values. Column (1) and (4) use the full sample, while column (2), (3), (5), and (6) restricts the sample to include only bison-reliant tribes, which we define as having ancestral territory that overlaps more than 60% with the original bison's range. In columns (3) and (6) we limit the sample to those aged 5-35. Standard errors clustered by tribe are in parentheses, $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 3: Correlation between Bison Reliance and Proportion of Children Ever Born Surviving in 1900 & 1910

	Full Sample			Bison-Reliant		
	(1)	(2)	(3)	(4)	(5)	(6)
Share lost btw 1730-1870	-0.0141	-0.0192	-0.0308			
	(0.030)	(0.030)	(0.035)			
Share lost btw 1870-1889	-0.104***	-0.105***	-0.106**	-0.0791**	-0.0590*	-0.0537
	(0.028)	(0.029)	(0.045)	(0.035)	(0.030)	(0.044)
I(1910)	0.0102	0.00397	-0.00497	0.0117	0.00135	0.00357
	(0.009)	(0.009)	(0.015)	(0.012)	(0.012)	(0.009)
I(Literate)		0.0533***	0.0535***		0.0765***	0.0765***
		(0.010)	(0.010)		(0.014)	(0.014)
I(1910)*Share lost btw 1730-1870			0.00216			
			(0.042)			
I(1910)*Share lost btw 1870-1889			0.0213			-0.00953
			(0.018)			(0.042)
Quadratic in Age	X	X	X	X	X	X
BIA Region FE	X	X	X			
Literate		X	X		X	X
Observations	14451	14451	14451	6040	6040	6040
Adjusted R^2	0.173	0.179	0.179	0.159	0.176	0.175
# of Clusters	126	126	126	48	48	48

Notes: This table reports OLS estimates of the relationship between child mortality and bison-reliance (equation 2). The dependent variable is the proportion of children ever born to a given woman who survive. Columns (1)-(3) use the full sample, while columns (4)-(6) restrict the sample to include only bison-reliant tribes, which we define as having ancestral territory that overlaps more than 60% with the original bison's range. We do not control for Bureau of Indian Affairs (BIA) region when restricting to bison-reliant tribes because of the smaller subset of tribes and lack of variation in these regional indicators. For specific variable descriptions and sources please refer to Section III.A and the online appendix. Standard errors clustered by tribe are in parentheses, $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 4: Correlation between the Speed of Bison Loss and Income Per Capita by Reservation in 2000

	Full Sample			Bison-Reliant		
	(1)	(2)	(3)	(4)	(5)	(6)
Share lost btw 1730-1870	-1304.9	-1618.0**	-1393.0*			
	(831.196)	(765.026)	(792.797)			
Share lost btw 1870-1889	-4663.6***	-3714.1***	-2862.6***	-2677.4***	-1809.5	-1551.0
	(799.784)	(895.968)	(871.810)	(946.595)	(1155.132)	(959.504)
Historic Centralization	1646.9	3314.6***	3117.7***	1009.4	2244.4*	2070.8*
	(1081.444)	(983.264)	(880.459)	(749.155)	(1166.109)	(1058.023)
EA Calories Agriculture	-233.1	-322.3	-280.0	-304.8	330.1	240.1
	(356.008)	(227.477)	(205.883)	(420.169)	(547.660)	(574.939)
EA Sedentary	28.44	1.312	-67.57	596.0	-1108.1	-1028.8
	(310.385)	(267.813)	(233.504)	(514.264)	(899.652)	(920.086)
Jurisdictional Hierarchy	-304.4	-688.6	-408.7	-1117.8*	-922.4	-819.9
	(920.736)	(635.831)	(644.461)	(607.072)	(697.842)	(881.371)
Wealth Distinctions	-315.7	622.5	453.7	2590.1**	3355.2**	3449.2**
	(990.589)	(597.040)	(599.235)	(972.510)	(1346.606)	(1378.452)
Population in 1600	23.53	5.129	43.42	-15.57	308.0	285.5
	(90.743)	(86.810)	(81.318)	(118.958)	(214.758)	(226.665)
Log Ruggedness	474.8	362.2	286.7	-511.4	-734.1	-608.8
	(399.866)	(270.997)	(264.949)	(608.695)	(566.159)	(488.526)
Forced Co-existence		-5185.3***	-4750.4***		-7705.2*	-6886.4*
		(865.058)	(885.303)		(3858.110)	(3532.312)
Indian War		-722.9	50.75		156.9	452.2
		(676.928)	(742.687)		(1251.482)	(1324.757)
Distance Displaced		812.7***	636.1**		477.3	553.8
		(287.241)	(245.191)		(1055.099)	(977.840)
Nearby Income Per Capita			0.360***			0.340
			(0.126)			(0.235)
Constant	12349.9***	5887.4	353.1	5897.1***	6820.6	-781.7
	(1515.866)	(3684.071)	(4079.599)	(1825.770)	(13182.215)	(14418.583)
Observations	195	195	195	72	72	72
Adjusted R^2	0.060	0.300	0.332	-0.027	0.262	0.293
# of Clusters	99	99	99	37	37	37

Notes: This table reports OLS estimates of the relationship between income per capita and bison-reliance (equation 2). The dependent variable is income per capita at the reservation-tribe level. Columns (1)-(3) use the full sample, while columns (4)-(6) restrict the sample to include only bison-reliant tribes, which we define as having ancestral territory that overlaps more than 60% with the original bison's range. For specific variable descriptions and sources please refer to Section III.A and the online appendix. Standard errors clustered by tribe are in parentheses, $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 5: Robustness: Accounting for Selection

	OLS (1)	Oster (2)	IV: With Montreal (3)	IV: No Montreal (4)
Share lost btw 1870-1889	-1551.0	-2030.3	-1826.0*	-1808.8*
	(959.504)	.	(1063.144)	(1062.897)
Constant	-781.7	.	-639.3	-648.2
	(14418.583)	.	(12999.292)	(13000.091)
Observations	72	.	72	72
R^2	0.413	.	0.412	0.412
# of Clusters	37	.	37	37
F-Statistic on excluded instruments	.	.	13.146	15.388
p-value for over-identification	.	.	0.457	0.3673
p-value for endogeneity	.	.	0.513	0.618

Notes: This table reports OLS and IV estimates of the relationship between income per capita and bison-reliance (equation 2). The dependent variable is income per capita at the reservation-tribe level. All columns include the full set of controls in Table 4 and include only bison-reliant tribes, which we define as having ancestral territory that overlaps more than 60% with the original bison's range. The F-statistic on the excluded instruments is the Kleibergen-Paap Wald rk F statistic; the overidentification test is the Hansen J statistic. For specific variable descriptions and sources please refer to Section III.A and the online appendix. Standard errors clustered by tribe are in parentheses, $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table 6: Correlation between Share of Bison Covering Traditional Territory and Income Per Capita Adjusted for Experience with Agriculture

	(1)	(2)	(3)	(4)
Share lost btw 1730-1870	-3253.9**	-610.6	668.8	-426.5
	(1460.738)	(1429.498)	(1508.064)	(1451.326)
Share lost btw 1730-1870 X AG Cal	834.0**	-348.9	-735.8*	-548.3
	(395.238)	(373.190)	(397.104)	(420.167)
Share lost btw 1870-1889	-6094.6***	-5137.3***	-4041.8***	-5251.9***
	(1375.641)	(1353.260)	(1468.226)	(1550.538)
Share lost btw 1870-1889 X AG Cal	1348.1	2499.3**	2775.2**	3060.6**
	(947.142)	(1089.520)	(1160.959)	(1187.192)
Cultural Controls	X	X	X	X
Colonial Controls		X	X	X
Contemporary Controls			X	X
Soil Quality Controls				X
Observations	195	195	195	195
Adjusted R^2	0.070	0.298	0.344	0.344
# of Clusters	99	99	99	99

Notes: This table tests whether the OLS estimates of the relationship between income per capita and bison-reliance vary based on pre-contact experience in agriculture (equation 2). The dependent variable is income per capita at the reservation-tribe level. "Cultural controls" include calories from agriculture, historic centralization, measures of nomadism, jurisdictional hierarchy, wealth distinctions, log ruggedness and population in 1600. "Colonial controls" include being involved in an Indian war, a measure of forced co-existence, and distance displaced from traditional territory. "Contemporary controls" include nearby income per capita, log distance to the nearest city, presence of a casino. "Soil Quality controls" include share of reservation land without constraints from excess salts, nutrient availability, nutrient retention, rooting conditions, oxygen availability, toxicity, and workability. For specific variable descriptions and sources please refer to Section III.A and the online appendix. Standard errors clustered by tribe are in parentheses, $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.